Developing an Integrated Approach to Understanding the Driving Forces of Deforming Western North America

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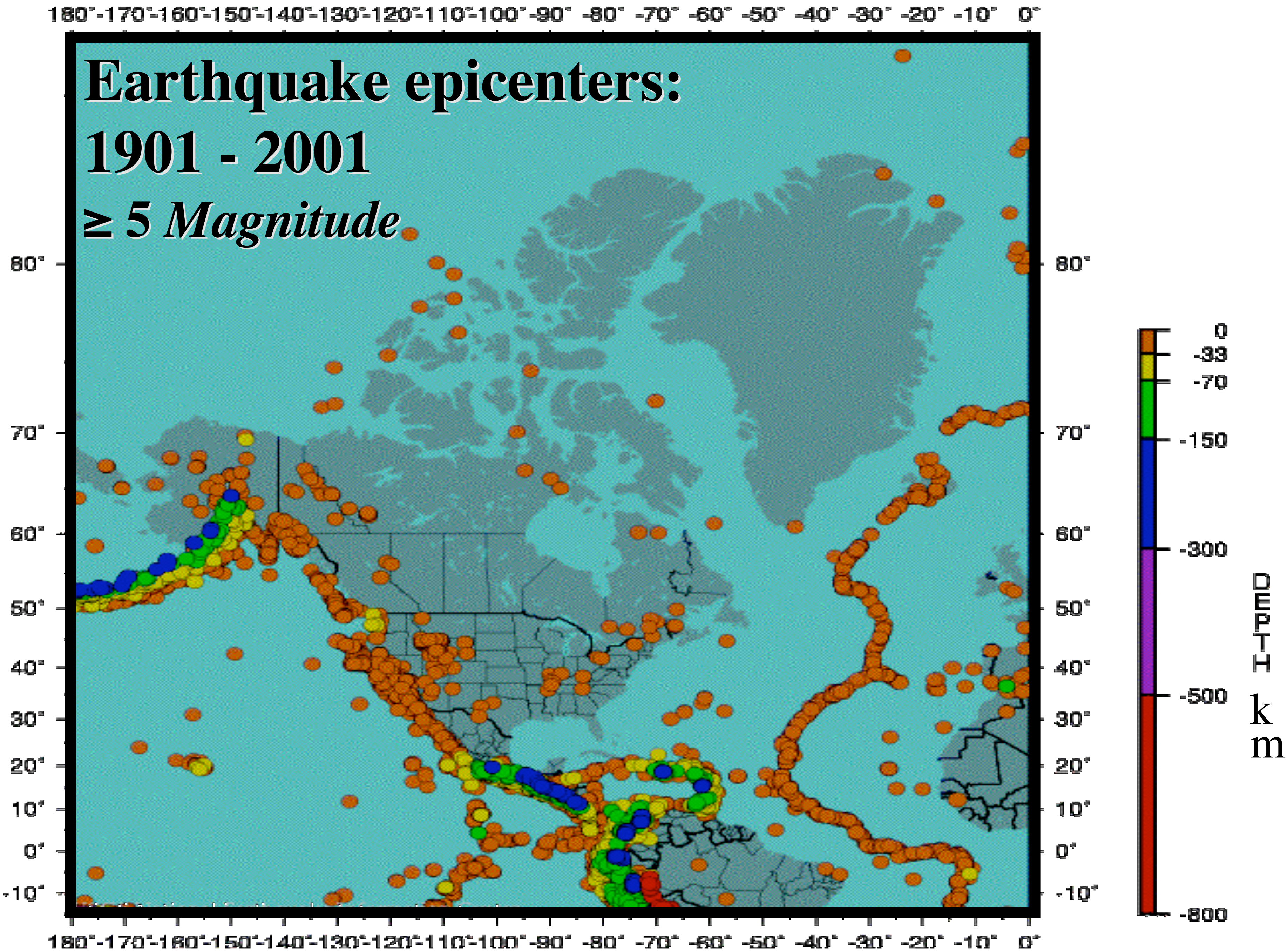
Lianxing Wen


Earthquake epicenters:
1901 - 2001
≥ 5 Magnitude
180° -170° -160° -150° -140° -130° -120° -110° -100° -90° -80° -70° -60° -50° -40° -30° -20° -10° 0°
80°
70°
60°
50°
40°
30°
20°
10°
0°
-10°
0
-33
-70
-150
-300
-500
-800
DEPTH
km

Motivation: quantification of the relative driving forces of continental deformation

Exploit increases in computational power and take advantage of newly available geophyiscal data sets

- Geodesy
- Seismology
- Topography
- Stress estimates
- Mantle tomography
- History of subduction

Integrated Geodynamical Approach

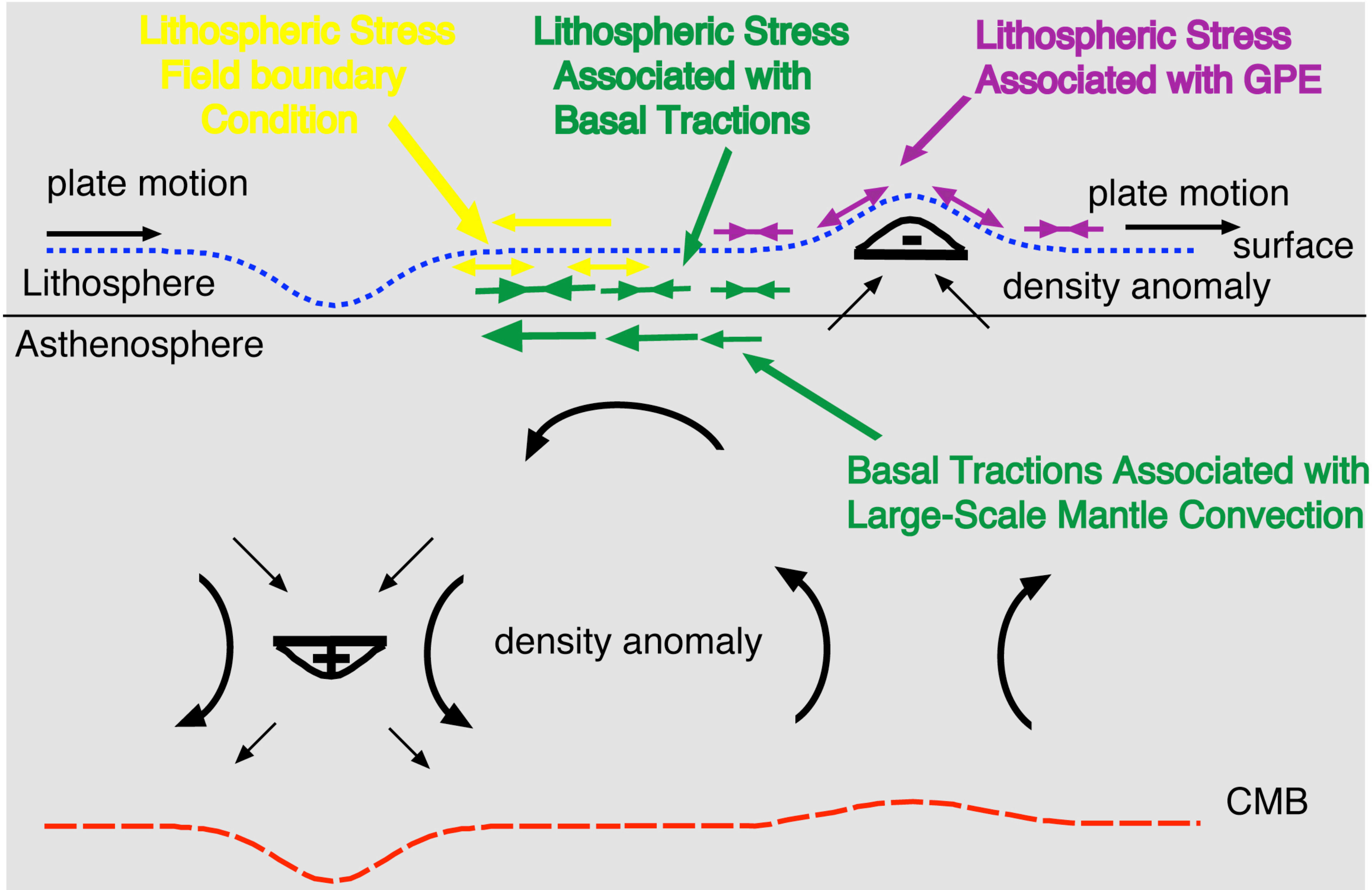
Quantify the total lithospheric deviatoric stress field
using the complete set of forces.

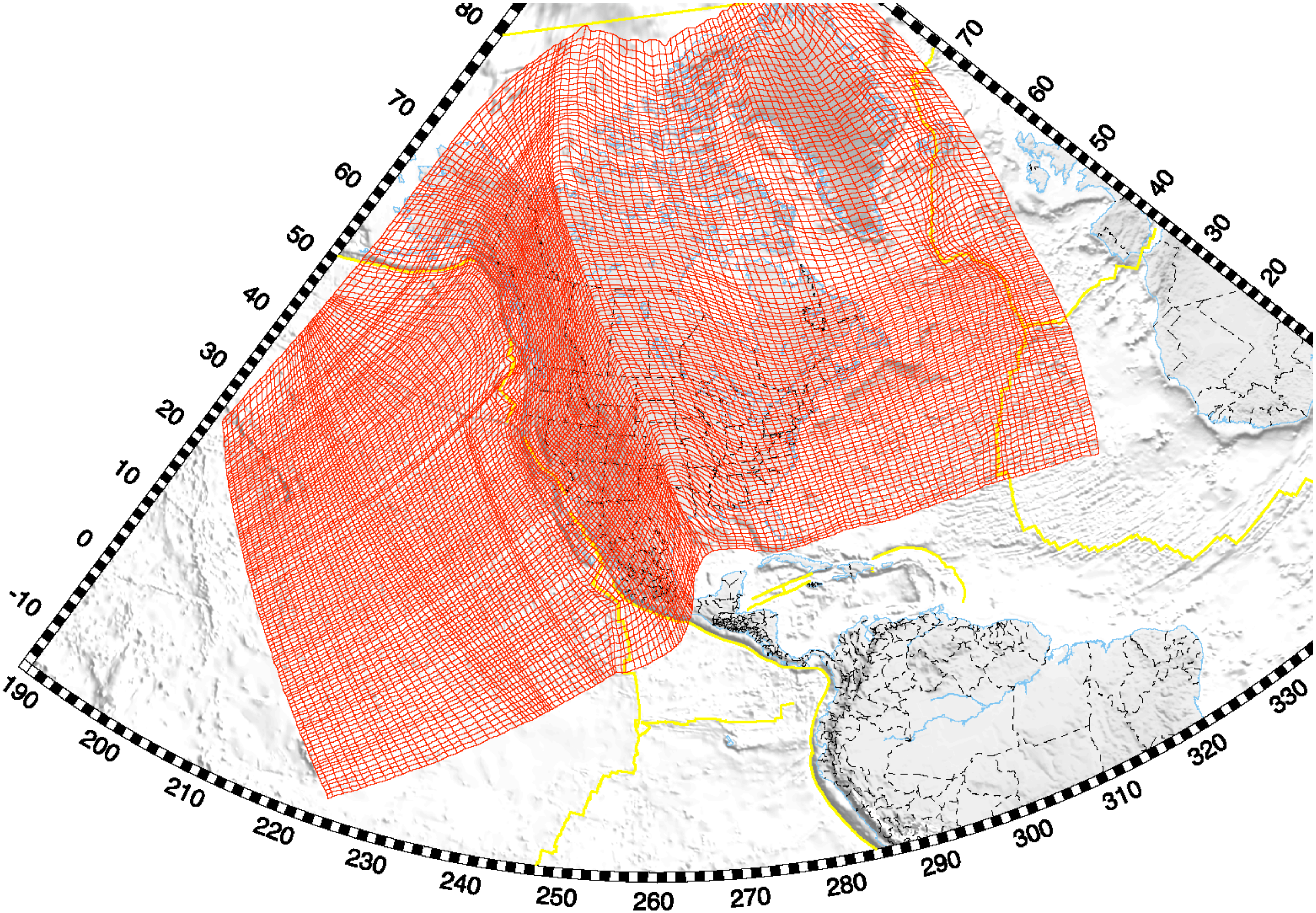
1. Body forces - resulting from density variation within the lithosphere ~ top 100 km

2. Basal tractions - provided as inputs from deep large-scale mantle circulation ~ 100 to 2891 km

3. Boundary forces - obtained by relative motion in the plate boundaries

A schematic of our modeling approach.

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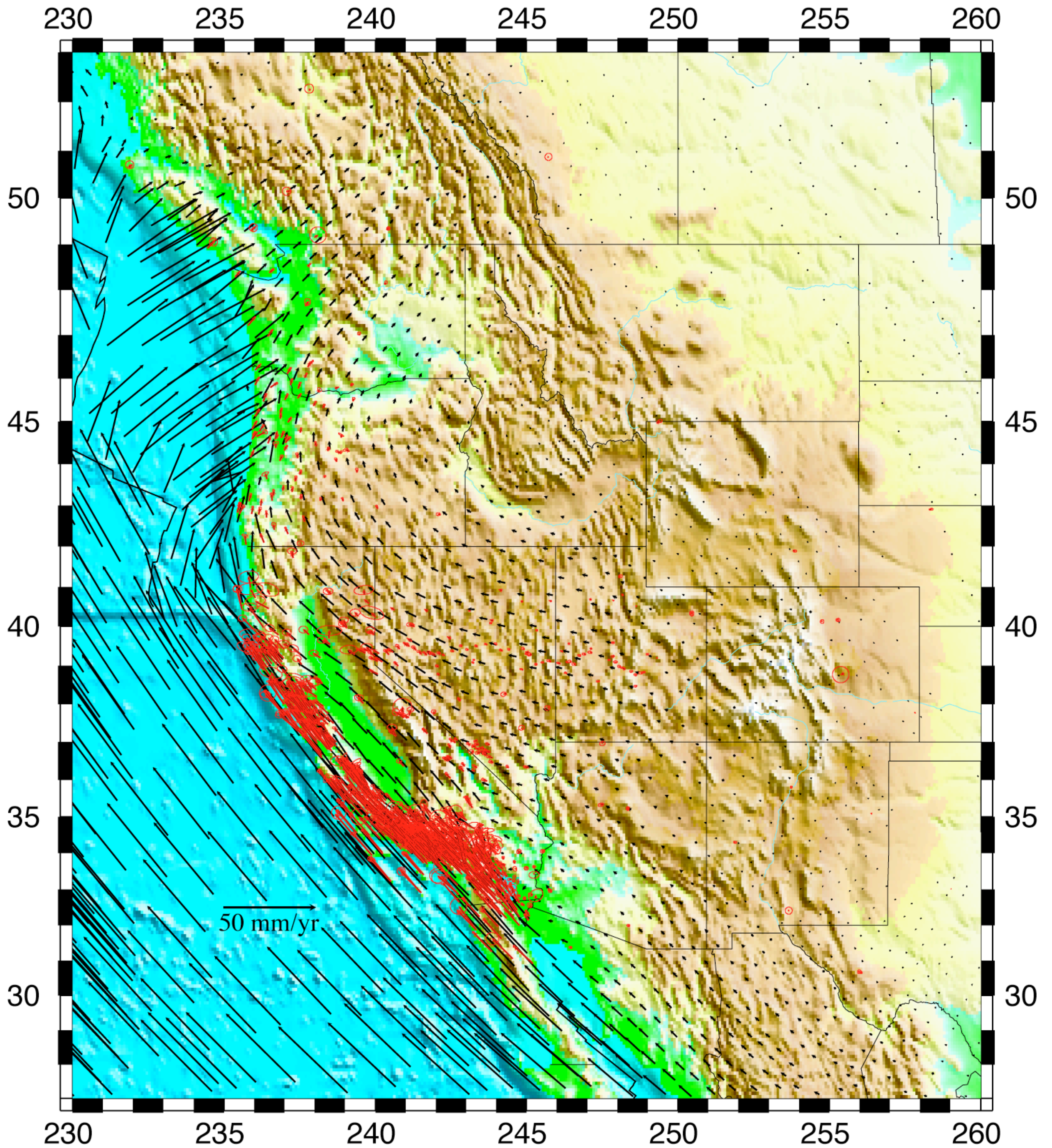


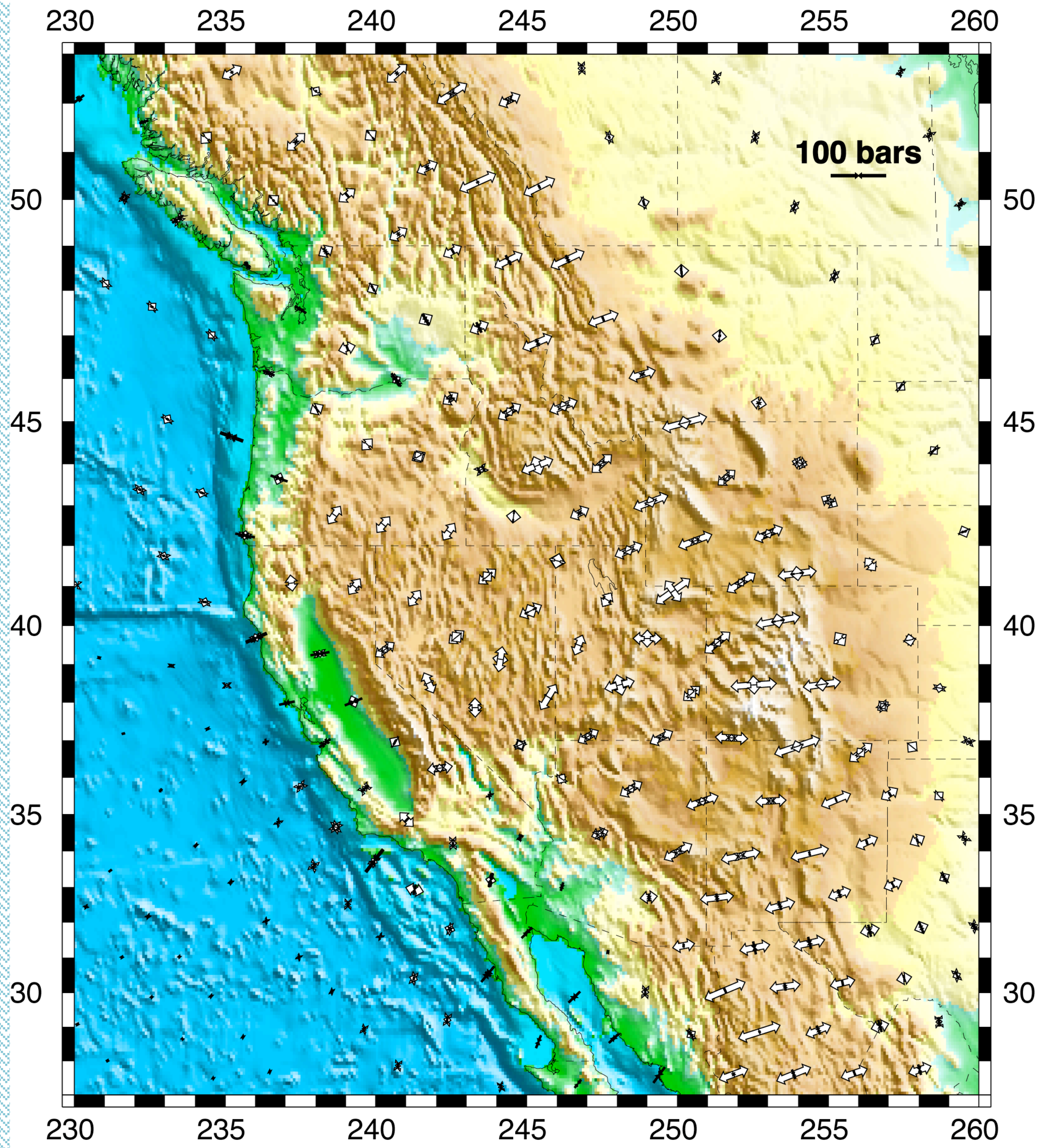
A kinematic model velocity field
(black vectors)
plotted relative to a North America reference frame.
Also shown are the GPS and VLBI measurements
(red vectors)
that were used to infer estimates of the strain rate.

Red ellipses contour the standard 95% confidence interval.

Body forces

The vertically averaged deviatoric stress field associated with GPE variations within the uppermost 100 km of lithosphere determined using the ETOPO5 data set

(assuming airy isostatic compensation)



P-wave mantle cross section

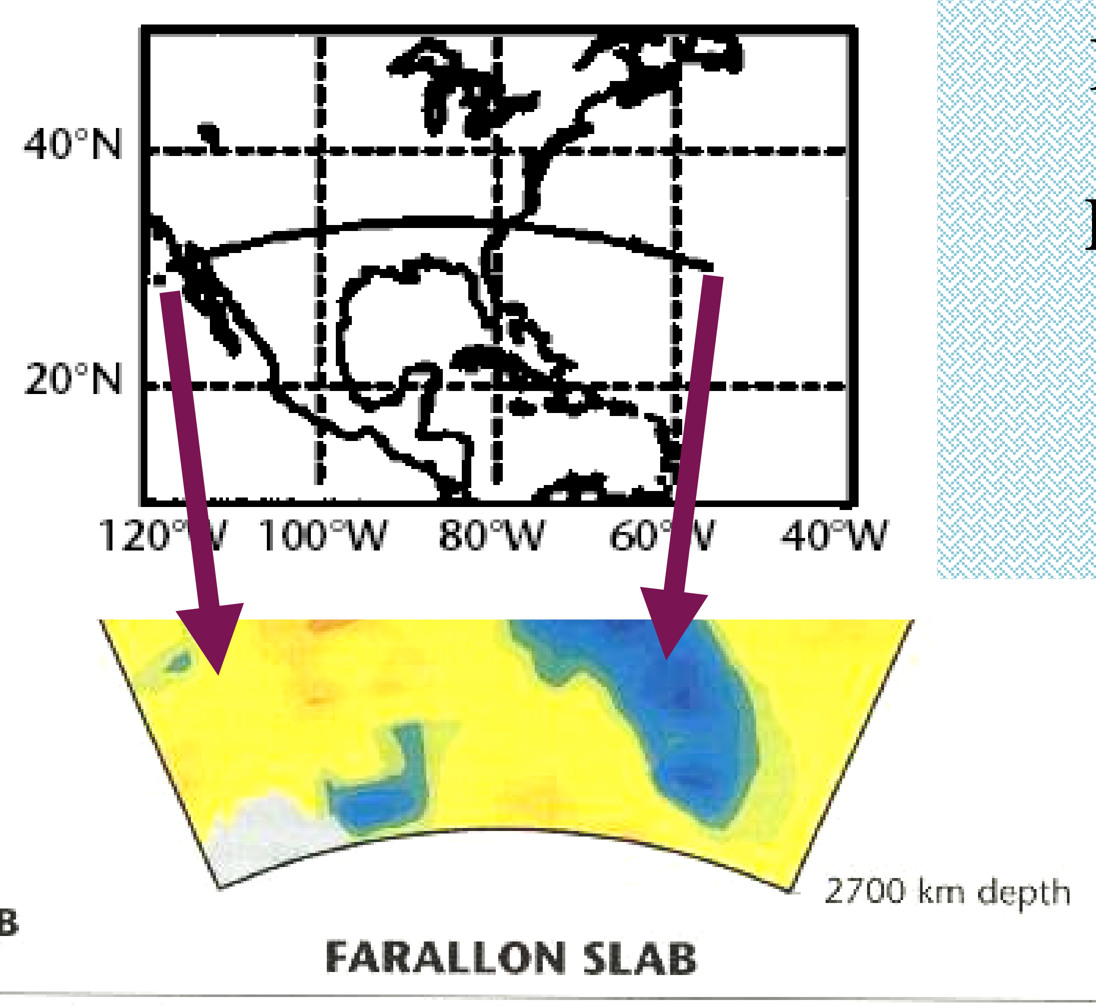


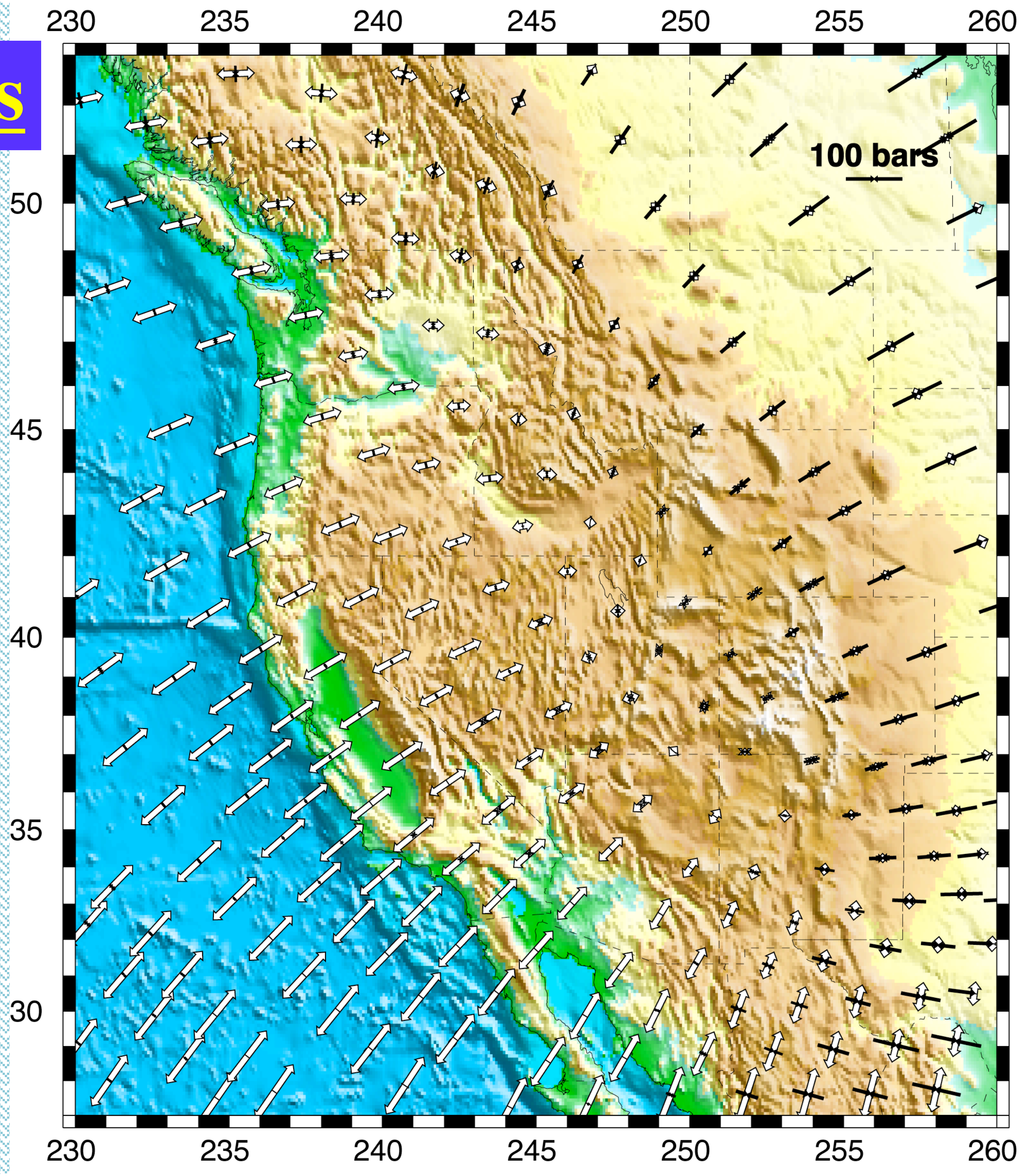
Figure 1. Cross sections of mantle P-wave (A) and S-wave (B) velocity variations along a section through the southern United States. The endpoints of the section are 30.1°N, 117.1°W and 30.2°N, 56.4°W. The images show variations in seismic velocity relative to the global mean at depths from the surface to the core-mantle boundary. Blues indicate faster than average and reds slower than average seismic velocity. The large tabular blue anomaly that crosses the entire lower mantle is probably the descending Farallon plate that subducted over the past ~100 m.y. Differences in structure between the two models in the transition zone (400 to 660 km depth) and at the base of the mantle are probably due to different data sampling in the two studies.

Blue faster
Red slower
$\Big\}$ **than average seismic velocity**

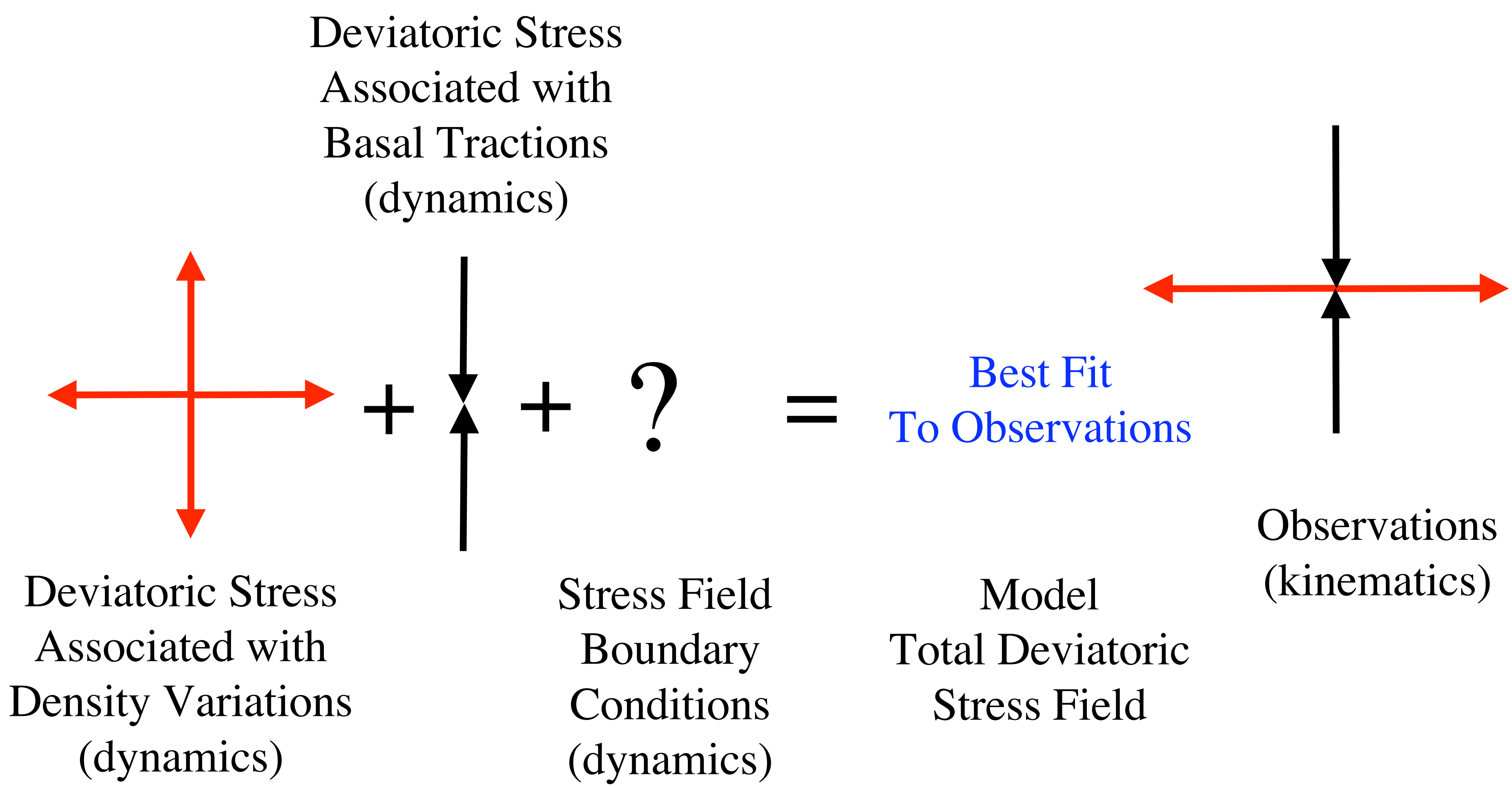
after Grand et al., 1997

Basal tractions

The vertically averaged deviatoric stress field associated with basal tractions vertically averaged over 100 km of lithosphere. The tractions are from a simple polodial flow field generated using an isoviscous mantle.

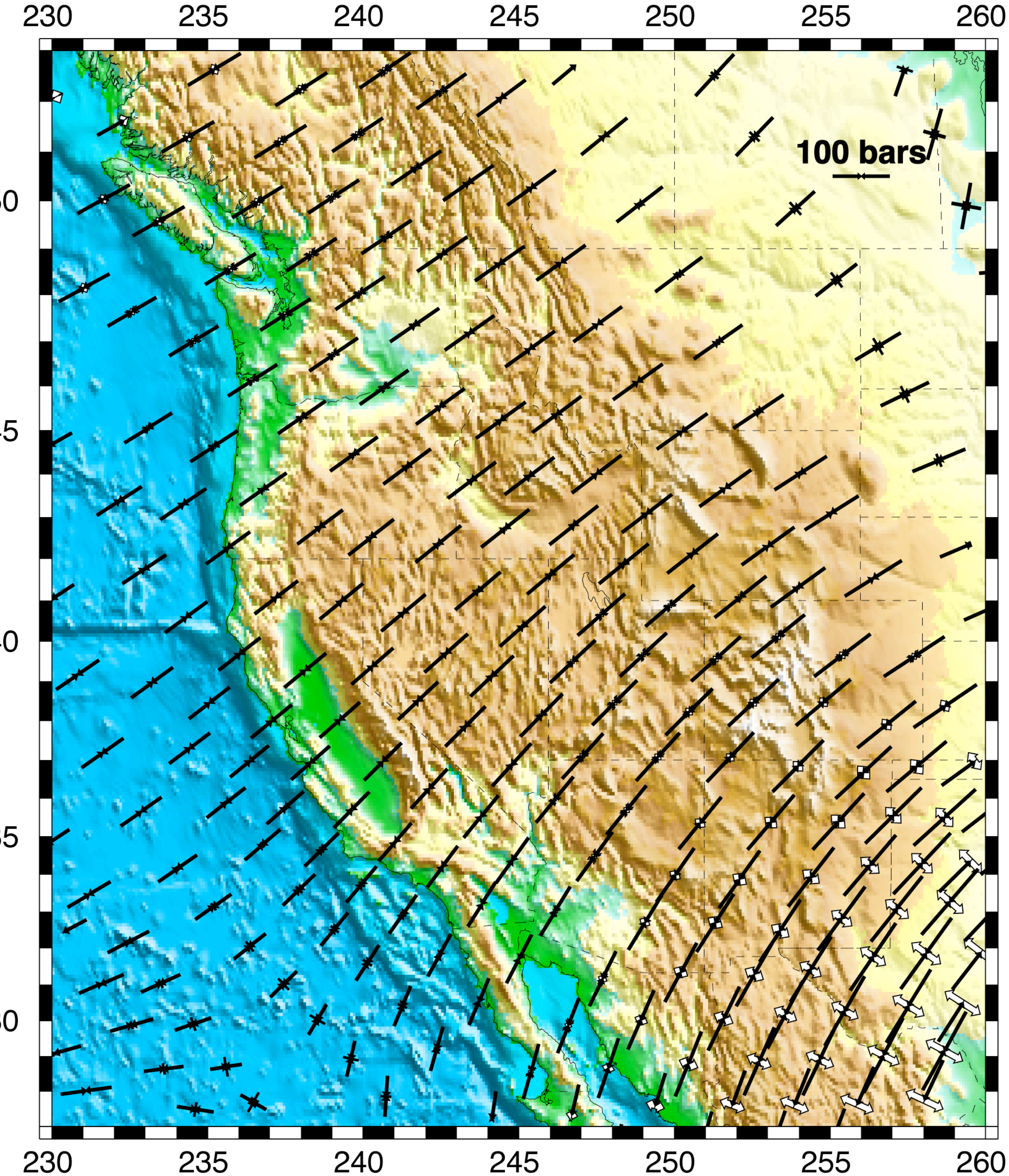


Stress Field Boundary Conditions

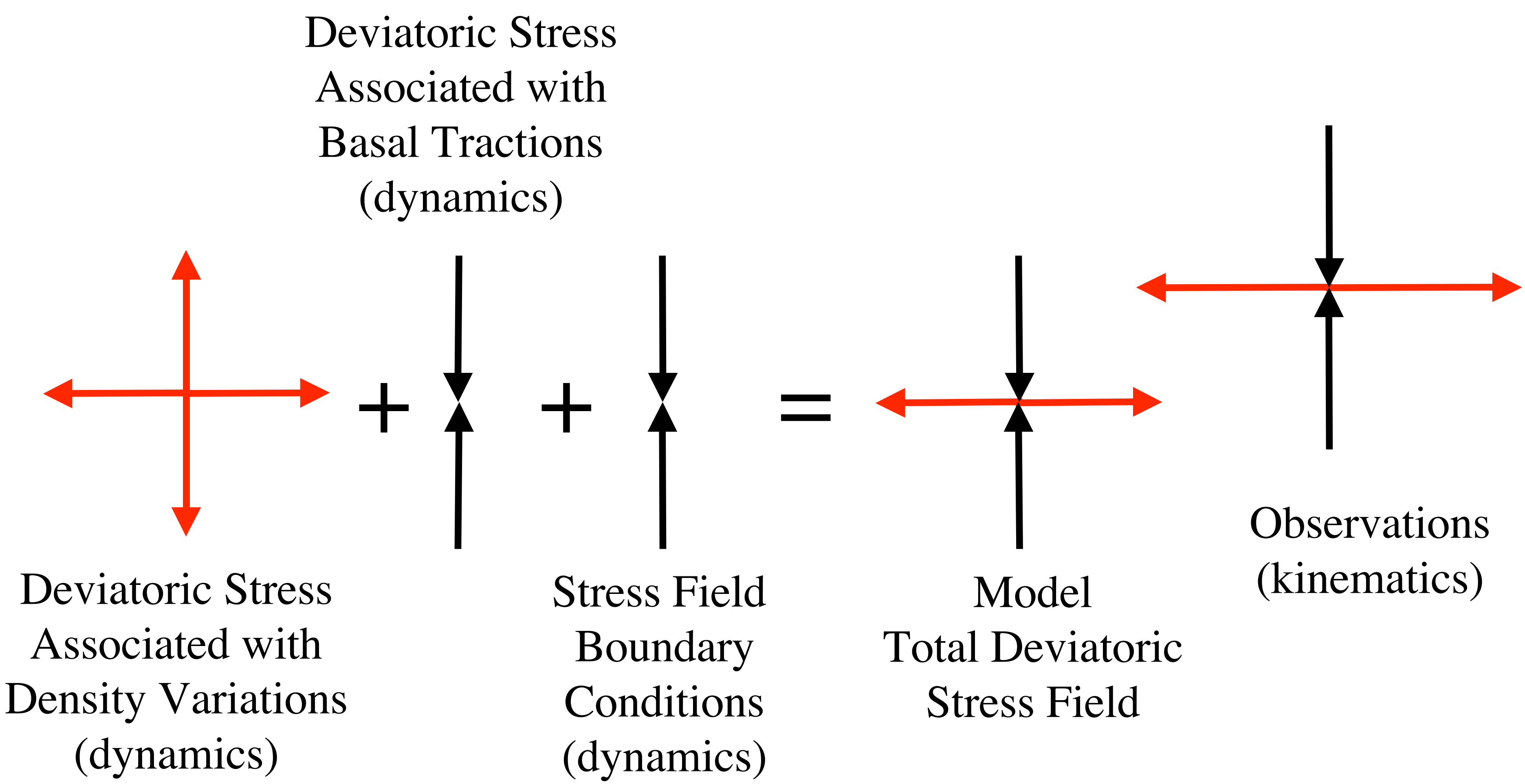


Boundary forces

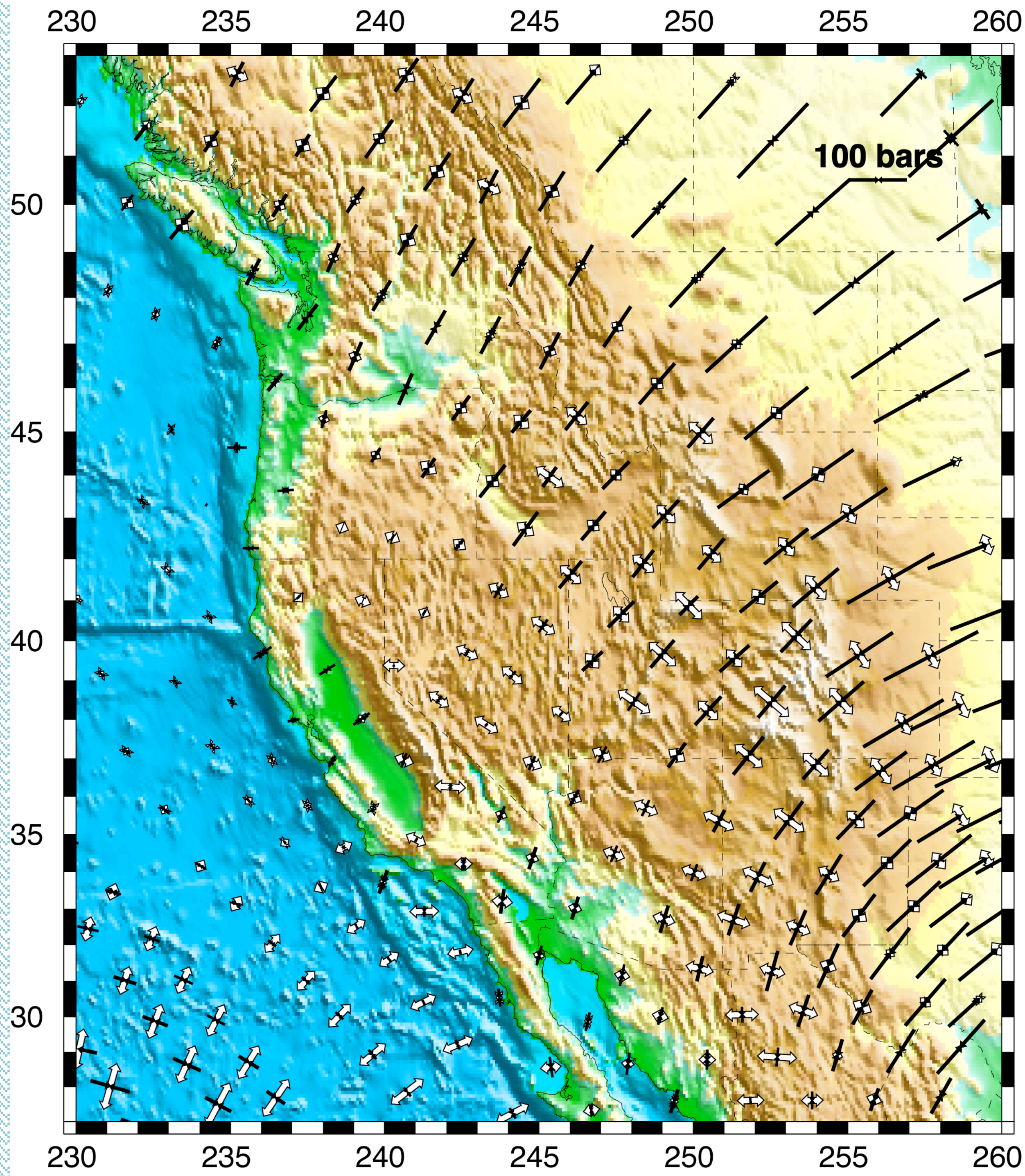
The stress field boundary conditions.



Stress Field Boundary Conditions



The total vertically averaged deviatoric stress field that is the linear sum of the stresses associated with continental deformation



Future Goals

Quantify the total lithospheric deviatoric stress field of deforming western North America

- Solve for stresses associated with body forces using different buoyancy models
- Improve our mantle convection model
- Solve for the deviatoric stess field associated with basal tractions globally
- Investigate other interesting tectonic regions
- Parallelize codes